

## Designing an Automotive Instrument Cluster for Increased Sound Pressure Level

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Nearly all vehicles have a chime or speaker on the dashboard instrument cluster for various alert functions. Increasingly, instrument cluster manufacturers are turning to speakers that produce multiple chime, alert and turn signal indicator sounds with higher Sound Pressure Level (SPL).

Higher SPL is needed to overcome interior noise, particularly at higher road speeds. Often, cluster manufacturers try to achieve higher SPL by increasing the power applied to the speaker. Frequently, the increase pushes the power above the level for which the speaker is rated, resulting in significantly diminished sound quality and speaker life expectancy. A superior, alternative method to achieve higher SPL is to apply basic acoustic principles, such as "separation" and sound "channeling."

Separation is a critical and often overlooked design consideration. As a speaker diaphragm vibrates, sound waves are produced by the front and back of the diaphragm. The front and back sound waves are equal in amplitude and 180° out of phase with each other. If the front and back sound waves mix, they cancel each other out, resulting in a greatly reduced sound pressure level. This negative effect can be eliminated in the cluster design by separating the front and back sound waves.

Sound channeling is another overlooked design consideration. In most automotive designs, the speaker is placed onto a printed circuit board (PCB) with the front of the speaker pointed towards the vehicle's engine. The PCB is enclosed in a plastic cluster housing assembled into the dense instrument panel. The resulting sound output is greatly diminished by the time it reaches the driver. However, a driver can experience greatly increased SPL by having the sound "channeled" toward him or her.



## Real World Results

These design concepts were put to the test in the 2010 Jaguar XJ and Land Rover Ranger Rover. Jaguar Land Rover models can travel up to 155 MPH, so the audibility of the alert functions at higher speeds is a necessity. To meet branding requirements and improve performance, the speaker was moved from the printed circuit board to the top of the instrument cluster. The desired sounds were achieved at less power by creating a direct sound channel toward the driver and providing total separation of the speaker's front and back sound waves.

## Another Method

Although acoustic considerations such as separation and channeling should always be included in the design, improvements to the speaker can also help to create the desired SPL. One of the most effective acoustic changes is the diameter, and thus the surface area, of a speaker's diaphragm.

A larger diaphragm does not necessarily produce a higher SPL at all frequencies but it does result in a higher SPL at low frequencies since diaphragms with large surface areas transmit low frequencies to air more efficiently than smaller diaphragms. As manufacturers develop instrument clusters to produce more pleasant sounds, speakers that can deliver low frequency content at a high SPL are critical.

The previous experiments tested speakers with a standard 30 mm diameter diaphragm, but speakers with larger 40 mm diaphragms can be used if there is space in the instrument cluster. Because there is more air resistance and the diaphragm is heavier in a speaker with a 40 mm diameter diaphragm, more power must be applied to drive it. Figure 3 shows that the SPL at frequencies below 400 Hz is significantly higher for the speaker with a 40 mm diaphragm.

## Conclusion

Selecting only a suitable speaker for an instrument cluster application is not enough

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to provide the driver with highly audible alerts. There are many acoustic effects that must be considered when designing the instrument cluster and its enclosure, such as channeling and separation, in order to fully realize a speaker's potential. Care must be taken to design the instrument cluster enclosure such that the front of the speaker is sealed off from the back of the speaker and the sound from the front of the speaker is channeled out of the enclosure without losing energy to its surroundings. To increase the sound pressure level at low frequencies, a speaker with a larger diameter diaphragm can be used but the same care must be taken to acoustically engineer it into the instrument cluster.

### **About the Authors**

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